Communications of the Association for Information Systems

Volume 9 Article 27

November 2002

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Recommended Citation
Chatterjee, Samir and Byun, Jongbok (2002) "Network Convergence: Where is the Value?," *Communications of the Association for Information Systems*: Vol. 9 , Article 27.
DOI: 10.17705/1CAIS.00927
Available at: https://aisel.aisnet.org/cais/vol9/iss1/27

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NETWORK CONVERGENCE: WHERE IS THE VALUE?

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ABSTRACT

The entire telecommunications industry is going through very difficult times. Rapidly changing technology, lack of good business models, and lack of visibility in the near-term for renewed growth all create an uncertain environment. Yet, the global Internet is becoming a multi-service network infrastructure that can potentially replace existing disparate voice and data networks. Although it is widely believed in the telecommunications industry that network convergence of voice, data, video, and images is an industry driver, not much attention has yet been paid to a key proposition: what value does network convergence bring to business and residential customers? This paper explains how different industries are converging; the technological, economic and regulatory forces that are at play and how the various customer segments can benefit from network convergence.

While technological advancement is transforming industry and business models rapidly, one question keeps coming back to haunt managers: Where is the business value? We illustrate the value proposition of convergence (for various players) by first explaining the paradigm shifts happening across industries and then highlighting the "high velocity spiral" of knowledge dissemination theory that is fueled by convergence.

KEYWORDS: convergence, global Internet, voice over IP, knowledge creation, service creation, business value

I. INTRODUCTION

Network convergence is a multi-faceted phenomenon that means different things to different people. However, everyone agrees that this phenomenon is real, is happening and potentially impacts all businesses. By network convergence we mean the integration of several media applications (data, voice, video, images) onto a common packet-based platform provided by the Internet Protocol (IP). The global Internet is becoming such a true multi-service infrastructure [Dunstan, 2001; De Serres and Hegarty, 2001].

The main workhorse for voice services for all businesses today is still the Public Switched Telephone Network (PSTN). It is based on circuit-switching technology. It is reliable, robust, and provides many advanced services in addition to basic calling. However, for data communication, enterprises rely on LANs and the TCP/IP protocol to send and receive messages and to share files and documents. IP networks are based on packet-switching technology, which proved to be very efficient for non real-time data transfers. Over the years corporations also relied on satellite and ISDN lines for limited video communication. Residential users, on the other hand, can choose video services over CATV network infrastructures. Each of these different networks is optimized for the distinctly different service type they support.

Voice Over IP. With the advent of the Internet and its increasing use as a commercial platform, it is possible to offer telephony services over the Internet using a technology known as Voice over IP [Schulzrinne and Rosenberg, 1999]. A number of video services ranging from conferencing, streaming, to on-demand are already demonstrated over IP networks [Wainhouse Research, 2001]. Service providers and carriers are beginning to upgrade their networks to carry voice and video together with data on their IP networks. The belief is that a connectionless IP network is cheaper to build and provision than a circuit-switched network. Moreover, there is industry-wide optimism that a converged voice and data network can be used to provide next-generation services, thereby increasing revenue opportunities.

For enterprises and residential users, the customers of these carriers and service providers, this change can cause significant impact on their existing infrastructure. The ramifications of upgrading legacy infrastructure into a converged infrastructure are not yet fully understood.

- What is the cost of upgrade?
- What business case justifies the upgrade?
- What value does this convergence add to operations?
- Perhaps a bigger question is: How does a converged network enhance strategic capabilities and help sustain competitive advantage?

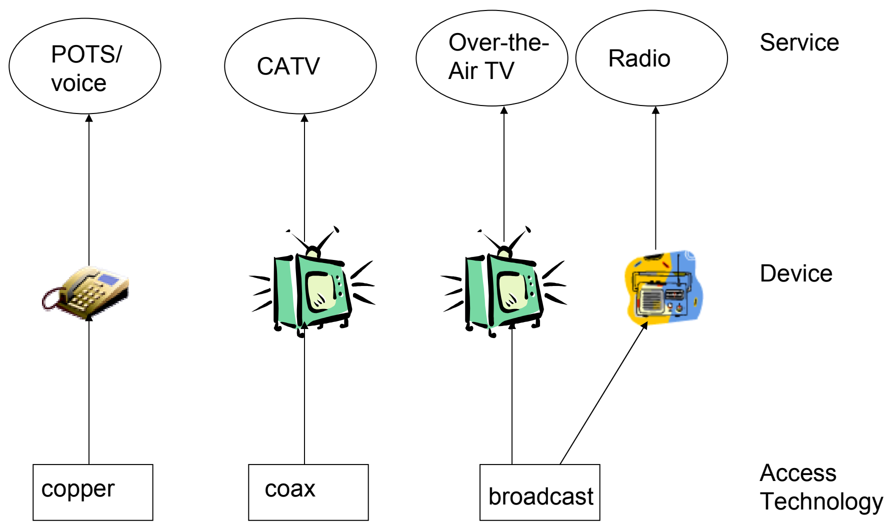
In this paper, we address these issues and present insights into the gradual evolution towards a true converged network. In Section II we present a discussion of how the Internet is completely changing the telecommunication services landscape. We then discuss the usage and applications of vertically integrated but distinctly separate communication industries from a business perspective (Section III). In Sections IV and V we show how a new converged network can be exploited for strategic advantage by enterprises. We next present some of the technical, economic, regulatory, and social challenges that remain to achieving a seamless converged network (Section VI). We conclude the paper by presenting a model that we call “high velocity spiral” to show the long-term implications of convergence.

II. EVOLUTION OF TELECOMMUNICATION SERVICES

The telecommunications industry, its revenue and business model, and its technology are changing quickly. The continuing process of deregulation combined with remarkable network technology advancement and the advent of new service offerings via the Internet provide a powerful push for evolution. Digitization of information is at the heart of this change.

THE PAST “OLD” STRUCTURE

Not too long ago (the early 1990’s), one could present a simplified illustration of the three major communication services that reached end-users at home or business [Clark, 1998] (Figure 1). Plain old telephone service (POTS) was carried over twisted-pair copper wires and a telephone device was used to talk and hear. Coaxial cables (coax) carried analog television signals that were distributed one-way through our TV sets. Over-the-air TV signals were broadcast by television stations. Radio programming, also carried over the air, was accessed through our transistor set.



Modified from [Clark, 1998]
Figure 1: Past Communications Industry Structure

Three important points about this simple old structure are:

- Delivery technology and the service are tightly coupled. The service providers who installed and maintained the copper pairs and central office switches understood the requirements of telephone service.
- This clarity about service and what specific technology was needed to optimize that service so that end-users received maximum value led to clear revenue and business models. Investment in infrastructure meant better and enhanced services in that business which led to greater profitability.
- In almost all cases, service and technology were provided by the same company, leading to a vertically integrated industry structure.

THE PRESENT "EMERGING" STRUCTURE

After the mid 1990's, this picture began to change significantly. With Internet service becoming a commercial success, several "old" industry players felt that perhaps it was better to be in multiple line of business, which would increase revenue and profitability. Along with the three common services, Internet service suddenly dominated the picture (Figure 2) and two new access technologies became commercial viable:

- wireless (or cellular) and
- satellite.

The solid lines in Figure 2 indicate existing service while dotted lines show reasonable possibilities. The several important points about this rather complex picture are:

- The vertical industry relations were replaced by a complex matrix structure.

- The Internet is positioned so that several services can be delivered over it and it can be delivered over all the access technologies.
- Besides the then existing end-user devices, several new devices (cell-phones, satellite hand-sets, web-appliances, PDAs, smart wrist-devices) are in the picture.
- Although not depicted clearly in the picture, the underlying technology for service delivery shifted to packet-switching and heavy use of web-based technologies.
- Various service providers are in multiple line of business and their networks are being used to deliver services for which they may not have been designed for optimal performance.

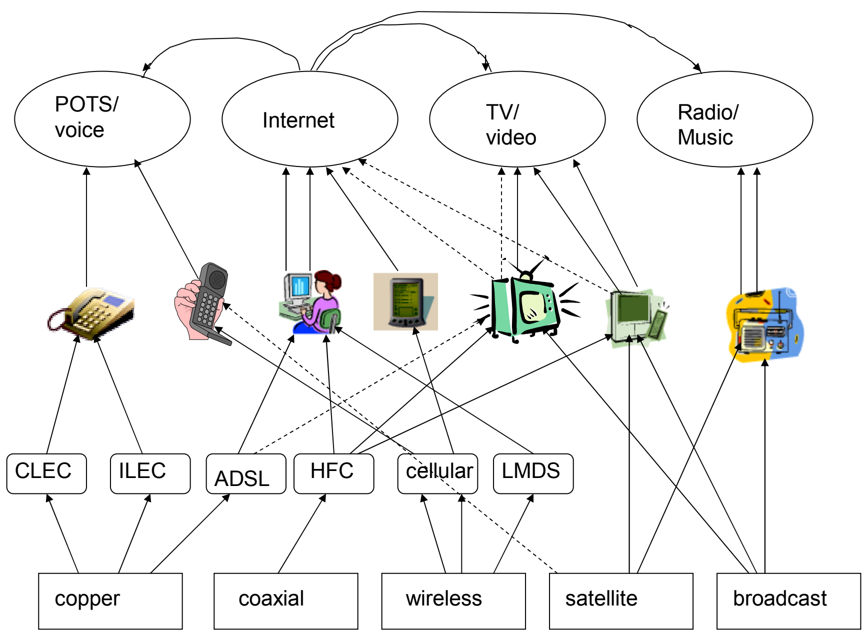


Figure 2: Present Complex Matrix Type of Industry Structure

THE FUTURE "POSSIBLE" STRUCTURE

Although it is extremely difficult to predict the future of the Internet, it is reasonable to believe that it will become the common "converged" infrastructure that will provide a host of existing services as well as a number of new enhanced communication services (Figure 3). What will be the type and nature of these services? What will be the implications on industry structure as these converged services evolve? To answer these questions, one needs to carefully understand two salient characteristics about services:

- The open structure of the Internet led to a flurry of innovations in a very short span of time compared to other service evolutions in the past. Hence it is absolutely imperative that the future course of the Internet preserves this open standardization process, which can be expected to further fuel unprecedented innovation rather than inhibit innovation as some of the present forces seem to indicate. While instant messaging is a neat application that emerged, however commercial (closed) implementation of AOL, Yahoo and Microsoft led to interoperability problems and user frustration.
- The type and nature of services that will be successful depend largely on the perceived value that they bring to enterprises and individuals.

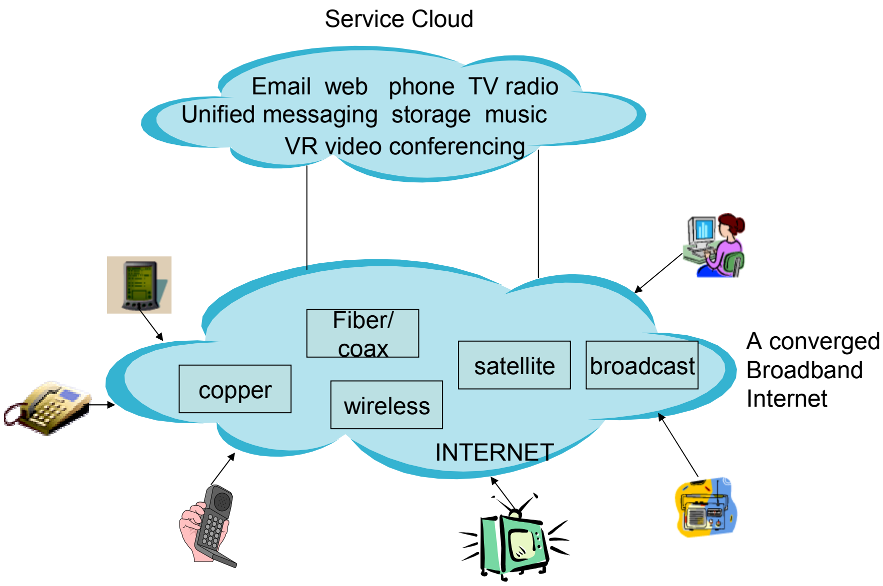


Figure 3: A Future View of “Converged” Network and Service Cloud

New services and business paradigms are being created by the development of several technologies at once (for example communications, networking, broadcasting and media); technologies that were developing more or less independently but that now don’t seem independent at all [Bartholomew, 1997]. Businesses are spilling into each other’s areas. Competition is opening up old protected economies. Political and national barriers are less of a factor than before. Access technology and access device will become seamless and we will begin to see the notion of service ubiquity. Technological convergence [Bartholomew, 1997] ultimately enables, “any client, any network, any bit, any format”. With convergence only one thing is certain, enterprises will see increased global competition, their profit margins will shrink, and only the nimble adaptive enterprise will still remain in business. Understanding convergence and its power is a key first step towards survivability.

III.ENTERPRISE CONVERGENCE – DERIVING VALUE

For each of the basic communication services (voice, data, internet, video), we look at a number of technologies within each service and the applications that are an integral part of businesses today.

VOICE TECHNOLOGIES IN ENTERPRISES

The telephone network, along with its basic and advanced voice services, changed the way businesses operate today. From a single person to small businesses to large corporations, all use the capabilities of the phone service to conduct business and provide value to customers. The success of the telephone as a business tool is largely the result of its ease of use, reliability, low cost, and high reach (nearly everyone has access to a phone). The phone network is robust, reliable, ubiquitous, and mature, with proven revenue and business models. Over the years the service providers introduced new services and applications that found their way into the business world, such as voice-mail, call center, audio-conference, and mobile telephony. Table 1 lists a number of voice-based applications in widespread use today.

Table 1. Voice-Based Applications and their Business Use

APPLICATION	DESCRIPTION	BUSINESS USE
Office PBX, Centrex	Connect phones through wired central exchange devices located on premise	Intra-business communication; communication within a building
Facsimile	Send text over phone line	Expensive way to exchange text documents; Provides records as a proof of business activities
Call Center	A facility to receive customer calls and support through corporate database access	Customer support and response; Improve customer loyalty; Find problems with current products and services
Telemarketing	Use customer database and customer service representatives to make sales call to potential customers	Cross-selling and up-selling for increased market share and additional revenue
Voice mail, call waiting, call forwarding	Provide routed message transfer; store, process and forward voice messages	Enhances customer and employee reach leading to productivity
800-number services	Toll-free calling for business customers	Better customer acquisition where suppliers want the business enough to pay for the call
Interactive voice response (IVR)	Provides easy menu-driven access to information and service	Order entry; shopping by telephone
Voice conference	A number of people talk to conduct business at preset times	Group collaboration; stock-holders and analysts meetings;
Text-to-voice, voice-to-text	Text information is read out and voice message can be displayed as text	Access to voice information over a PC; hearing emails read out on cell phones

Although these technologies matured and found widespread use, the phone system does not integrate with other forms of information (e.g., corporate databases, web servers, video object servers) easily. Internet telephony potentially changes the way we work with voice services [Schulzrinne and Rosenberg, 1999; McKnight, 1997].

DATA COMMUNICATION SERVICES

Enterprises built LAN/WAN infrastructure primarily to introduce client-server based data communication applications. These networks use packet-switching and provide high-speed connections to corporate servers. Most of these applications are migrating to TCP/IP and web-based technology. Table 2 lists potential applications that are successful in corporate environments.

The trend now is to migrate all of the data applications in Table 3 into the TCP/IP Internet or Intranet and provide web-based user interfaces to access the services from anywhere on the Internet. A more recent trend is to enable these applications on Personal Digital Assistants (PDAs) using microbrowser and Wireless Application Protocol (WAP) capabilities [WAP Forum, 2001].

INTERNET SERVICES

In the mid-1990s, enterprises started adopting the Internet as a core IT strategy. While initial efforts were designed to create web sites to give the company a virtual presence, most of the later efforts went into building robust e-commerce and e-business systems. Table 3 lists business applications of Internet services.

Table 2: Data Applications over LANs

APPLICATION	DESCRIPTION	BUSINESS USE
OLTP (Online Transaction Processing)	Use online input devices (scanner, keyboard etc) to collect the business data concurrently	Real-time order data collection; help in internal decision making
File/Document Sharing	Using the file transfer protocol (FTP) to send or receive data files	Exchange business documents and data
Management Information Systems, Knowledge Management Systems, Decision Support Systems	Access to specialized decision-support and knowledge management software for managers	Business decision making; share corporate information and knowledge; use as strategic advantage
Data Mining/ Data Warehousing	Use chronological data, keywords and pattern matching techniques to find historic patterns of data or information	Understand user demographics better; establish sales patterns by region, markets and international; Estimate future events;
CAD/CAM/CAE (computer aided design, computer aided manufacturing, computer aided engineering)	Use drawing tools and sharing abilities of the computer to improve the quality and speed of design, manufacturing and education	Shorten the time to build and market; Improve the quality of design and products.
Groupware	Software tools to share documents, email, and files; discuss projects	For example, Lotus Notes for collaborative work
Telecommuting/Remote Access	Accessing corporate resources from home or other remote locations	Providing flexibility to employees to be more productive

Table 3. Internet Services and Their Business Use

APPLICATION	DESCRIPTION	BUSINESS USE
Web Site	Develop a corporate web site by using HTML, HTTP and other protocols.	Web access; Intranet and Corporate knowledge portal; Customer service portal;
E-Commerce	Buy or sell products through corporate web site to the customer	Sell products and services; Provide rich information to the customer (order tracking, product information, shipping and delivery status); Save time and cost of business transaction through online ordering)
E-business	Linking all the suppliers and partners on the value chain to each other and to customers	ERP, CRM, Supply-Chain Management; Reduce inefficiency and enhance supply-chain value; Faster and cheaper operations;

VIDEO AND TELEVISION SERVICES

In the past, enterprises relied less on video and television services to conduct business. However, with the recent downturn in economy, reduced revenue and increased threats to travel, video-conferencing services are increasing [Glassner, 2001]. Video-telephony over the Internet is expected to be a viable market in the near future. Video-on-demand, video streaming, and satellite news gathering are examples of video-services being adopted by corporations. E-learning environments that use audio and video collaboration tools are now in regular use by Fortune 500 companies. High-definition TV and holographic projections of images (tele-imersion) are future applications that will likely find their way to corporate use.

IV. THE VALUE PROPOSITION FOR CONVERGENCE

A number of drivers lead to the transformation to converged networks. In this section, we focus on four stakeholders (service providers, enterprises and corporations, business end-users, and residential users) and analyze their case for adopting convergence. Each stakeholder derives his or her own business value from a new converged network.

SERVICE PROVIDERS

In an environment where convergence is eradicating boundaries between telecommunications, computing, and entertainment, what can service providers do to succeed or even survive? The successful service provider will:

- Deploy an efficient, robust, cost-effective multi-service network infrastructure
- Offer a vast array of value-added, customizable enhanced services
- Make money delivering these services

These objectives are not really new. What gives them a new flavor is the increasing rate of technological advancement that is leading to the advent of an all-IP network [De Serres and Hegarty, 2001]. The Internet potentially can unify all media types (voice, data, and video) into a global infrastructure that delivers enhanced services. However, service providers face extreme competition because of deregulation. Competition brought service rates down, a trend that is likely to continue. Advances in optical networking made abundant bandwidth a commodity. Hence, it is becoming more and more difficult for service providers to compete on price.

Service providers must embrace convergence since they know that service differentiation will be the only weapon against the threat of competition. The number of ways to differentiate is relatively infinite within a converged infrastructure that is simply not possible with current vertical networks (Figure 1). The new converged network will span multiple domains (wireline and wireless, national and global, public and private) and perhaps for the first time, service providers will be able to customize telecom services for their clients at a price they are willing to pay.

ENTERPRISES AND CORPORATIONS

The business case for enterprise adoption can be seen from the growth of Voice over IP (VoIP) technology. VoIP is explained in Sidebar 1. In a Business Week survey [Baker, 2000], VoIP, which accounted for less than one percent of global telecommunications (Telecom) traffic in 1999, is expected to increase to seventeen percent (17%) by 2003 and more than thirty percent (30%) by 2006. Frost & Sullivan [Frost & Sullivan, 2001] forecasts that by 2006 the total VoIP traffic could reach 2.6 trillion minutes and revenues could surpass $100 billion. In 2001, VoIP traffic accounted for 10 billion minutes and over 6% of the total international traffic, 160 billion minutes. [Telegeography, 2002] This figures excluded PC-to-PC communications and private network traffic data.

SIDEBAR 1
VOICE OVER IP (VOIP)

VoIP encodes human voice into IP packets that are then routed across the Internet to its intended destination. The popular modes of using VoIP have been PC-to-PC, PC-to-Phone and Phone-to-PC. In the later two cases, an IP telephony gateway is required to connect the two worlds of circuit-switched public service telephone network and packet-switched Internet. In the first mode, a true converged network is assumed. To find the calling party, a signaling protocol is needed. Presently two International standards (H.323 and SIP) do the job [Hamdi et al., 1999].

Within the enterprise, although convergence has been talked about before in the form of Computer Telephony Integration (CTI) [McKnight, 1998], VoIP provides a far richer set of services much cheaper. Some of the value proposition and benefits of VoIP include:

- *Lower cost* – call tolls are less expensive by bypassing the public service telephone network. Because an IP phone call takes place across a data network, long distance calls becomes local. This arrangement lowers telecommunications expenses, particularly when placing calls or sending facsimiles internationally.
- *Maximize network bandwidth utilization* – A typical two-way IP telephony call occupies 25% or less of the bandwidth of a traditional voice call. And, because the voice is delivered as IP data packets, it can travel over the same data channels as any other data. The result? More network traffic over fewer leased lines.
- *Convergent and enhanced applications* – From opening up new business opportunities to supporting interactive Web pages, IP telephony provides value-added applications to businesses. For example, a telemarketing company based in New York City can install IP telephony gateways in its headquarters and its Houston office. By calling through the IP telephony gateway to access Houston prospects, the company may be able to service a new market without incurring traditional long-distance charges for each call. Or, a company may promote its products on the Internet by providing a "Talk-to-Agent" web application that helps businesses turn web surfers into customers with the click of a web icon. Speech recognition technology will enable new convergent applications especially in the wireless services
- *Tie-line replacement* – Businesses maintain expensive PBX and tie lines that interconnect branch offices with headquarters. VoIP performs the same function at less cost.

INDIVIDUAL BUSINESS USERS

For the employee within the corporation, convergence provides access to any medium of information from anywhere at the right time. A converged network reduces the number of devices that people usually carry to access information. Instead of a cell phone, a PDA, and a laptop, a single device would be sufficient for accessing information and supporting decisions. IP provides the universal connectivity. By working with the service provider, each division within a company or even each employee could customize the information that he or she receives. As a result, sales and marketing people would be able to respond better to customers than they do now.

Business users spend most of their time on computers or some form of hand-held computing device. By providing business information in a richer multimedia form (video, images, and audio), users can become more effective and productive in their daily work.

The major motivation of the company is 'decreased total cost of ownership' [Rischpater, 2001]. If the devices are integrated, the total cost of ownership and operation will be decreased. Enhancing mobility is another driver. [Rischpater, 2001]

RESIDENTIAL USERS

The trend to interconnect all household appliances and devices will be a strong driver for converged network capability within the home [Chatterjee et al., 1998]. The online experience of e-commerce, the ability to save and reuse information (TiVo, Xbox) and the ability to search, retrieve, and store digital music on home servers should be strong enough motivation for residential users to invest in the converged infrastructure at home. Most end-users prefer simplicity and value. To that end, the idea of getting all media services from a single broadband provider and the ability to pay a single bill is enticing. However, companies failed to deliver on that and the "single bill" concept remains a myth [Winkler, 2002].

V.SERVICE CREATION POSSIBILITIES

No technology or service survives without sufficient customer demand. A viable business is created only when there is a customer at the end of the value chain who is willing to pay for the product and service. To illustrate, consider the desktop. The desktop is where a service touches the end user, and for both service providers and network equipment vendor's success at the desktop is critical [Ubiquity Corporation, 2000].

A typical business desktop contains

- a telephone that works,
- a PC that runs business applications (most of the time successfully),
- perhaps a cell-phone that works with poor quality (and you pay a lot), and
- a PDA that is handy in storing information,

each working on its own. Yet, time and again the user says: "I wish these worked together". Convergence and its emerging service architectures can put these elements together seamlessly. Moreover, for the first time, the possibilities of integrating these technologies and creating new applications are only limited by our imagination [Leppik and Tan, 2000]. Add e-business infrastructure to the desktop, we soon start to see a powerful converged supply-chain that, in real-time, can delivers improved performance and efficiency. Integration with enterprise directory servers and making communications secured via encryption and other modes can provide an even more powerful platform. A list of potential new enhanced services is shown in Table 4.

Table 4: Possible Enhanced Services with Network Convergence

CONVERGED SERVICE	DESCRIPTION
Intelligent Call Management	When a call arrives at a VoIP endpoint and the person does not answer, it is possible to check the calendar application, locate the user, and ring at that location. Conversely an end-user may access a web-based interface to list the preferred way of reaching him or her based on time of day and other routing parameters.
Presence management	When we dial the phone, the person may not answer. Presence technology on the Internet shows whether the person is logged on somewhere on the Internet. One can immediately reach him via presence-enabled dialing on VoIP software. While intelligent call management deals with routing, presence uses peer-to-peer techniques to connect two users with voice or text. Presence even allows users to choose "do not disturb" or "gone out of room" features.
Virtual Call Centers	Using enhanced caller ID with picture and screen pop-ups and interfacing with the customer database application, call centers can be completely restructured through VoIP technology.
Unified Messaging	Unified messaging enables users to communicate using email, fax, and telephone by making the access device independent of the media format. You can hear your email read out to you via the phone while you can send/receive fax on your PC. The concept is not new but the way it is presently supported is expensive. With the convergence of voice, fax, email, and video onto one network, it becomes increasingly easier to deploy a unified messaging platform.
Games and wireless	Extension of VoIP to cell-phones is a natural one for the advantages of mobility. The integration with online games and music delivery can perhaps create a big revenue model for carriers and service providers.

ENHANCING THE SUPPLY-CHAIN

Over the past several decades, corporations invested in IT projects that led to efficient production planning and control. Up to the 1990s, using IT to solve production problems involved suppliers and customers as well as the organization. Since the 1990's, logistics or supply chain management is a business necessity [Keil et al., 2001].

Other new technologies (such as enterprise resource planning (ERP) and customer relationship management (CRM) systems) also proliferated. What these projects have in common is an attempt to consolidate large amounts of data about business operations that executives can use in decision-making.

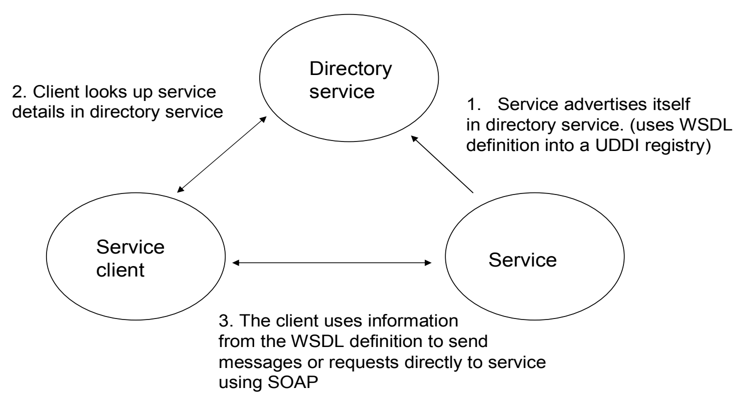
Effectiveness and efficiency of any supply chain depends on the visibility that can be gained from material flows, inventories, and demand throughout the pipeline. Without the ability to see down the pipeline into end-user markets, to read actual demand, and subsequently to manage replenishment in real time, the system is doomed to depend upon inventory.

SIDEBAR 2
WEB SERVICES

Web services attempts to provide tools by which enterprise software systems can easily talk to each other. ERP and SCM systems tried to do that in the past; however, the attraction of web services lies in the ability to wrap existing business logic and make it available using open standards. The service interaction model is shown in the diagram below.

1. A business object advertises its object reference in the directory service.
2. The client then must look up the reference to the business object in the directory service.

3a. The client then asks the business object to create a service object instance. The business creates a service object and returns an object reference for it to the client.
3b. The client directly uses the service object created by the business.
3c. The client destroys or releases the service object when finished with it, depending on the underlying middleware's object-lifetime semantics.



The biggest problem with existing IT solutions is that these systems often lack reliable, timely connections to the business "on the ground", where work actually gets done. In manufacturing, the situation is particularly acute. The best ERP software, for example, can predict a factory's output capacity and try to synchronize it with demand, but it doesn't know what's going on in factories from day to day. For that, companies need real-time application integration software, which is facilitated by convergence. Floor managers can send voice inputs on current status and mid-level managers can consult in real-time with the supervisor about the particular issue with inventory.

One of the key success factors in supply/demand chain management is information management. The material flow downstream from the suppliers through manufacturing to customers is thin and, as much as possible, controlled by daily consumption in order to guarantee the availability of goods and at the same time minimizes inventories. The information flow upstream across the value chain can be described as “thick”, because a lot has to be conveyed in a meaningful manner so that demand and supply can be met effectively.

Such real-time supply chain applications are good for extreme production environments (companies which mass produce volumes of products with strict delivery times). For other companies, similar services, tightly integrated with other aspects of business, can be provided by emerging web services. Integrated web services [Vinoski, 2002] are business applications that share data with other applications over the Internet, such as an invoicing system that links to an accounting program. With standard, consistent interfaces, such Web services can greatly simplify the process of integrating applications throughout a company. As converged networks mature, Web services will become commonplace. It will be easier and easier for companies to link their enterprise information systems with the production processes where work actually gets done.

VI. CHALLENGES IN BUILDING CONVERGED NETWORKS

While we are currently at the early-adopter stage of acceptance of converged networks, several challenges still remain. As shown in Figure 4, some are technical, while others stem from economics, regulatory and policy issues, and social acceptance of the new technology. This section describes each of these challenges.

TECHNOLOGICAL CHALLENGES

Although several technical challenges face converged networks, we briefly discuss two fundamental issues:

- The debate of end-to-end design versus smart network
- Quality of service

End-To-End Design The Internet’s design philosophy followed the end-to-end design approach since its inception [Blumenthal and Clark, 2001]. The end-to-end arguments concern how application requirements should be met in a system and where functionality should be placed within systems to achieve the best performance and minimize redundancy. As a consequence, Internet functions are implemented “in” the Internet as well as at the “edge” of the network. Functions “in” the network are implemented by routers that forward packets. They remained simple and general. The bulk of the “smarts” are implemented at the edge by such applications as e-mail, the web, and multi-player games. They reside in software on the clients and servers attached to the “edge” of the network.

This design concept proved successful and robust for the Internet and is able to support new and unanticipated applications. However, a number of recent trends threaten this design. The rise of new stakeholders, ISPs, new government interests, the changing motivations of a growing user base, and the lack of a trustworthy user community may, together, compromise the original Internet’s design. Emerging enterprise requirements are adding a number of functions to the core of the network that may prohibit new application development. These requirements include firewalls, traffic filters, network address translators, and the several new quality-of-service mechanisms being proposed by the Internet Engineering Task Force (IETF).

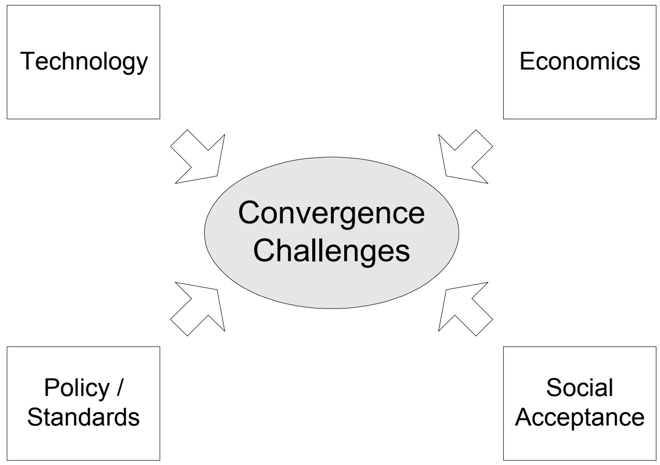


Figure 4. Convergence Success Depends on Multiple Areas and Issues

Quality of Service (QoS). The second critical technical issue is how to guarantee quality-of-service for real-time voice and video applications. Today's best-effort Internet service does not guarantee delivery and may even arbitrarily delay packets to their destination. Data applications such as e-mail and web may adapt to delay but conversational voice and video conferencing demand strict delay bounds. Several QoS architectures are being developed and tested to achieve these guarantees. Besides overcoming the network-imposed delay, improvements are needed at the CODEC level and in reducing software processing times.

ECONOMIC CHALLENGES

As the market for differentiated quality of service expands, economic approaches are as vital as technology solutions. The flat-rate pricing model adopted by virtually all Internet Service Providers needs viable alternatives in a converged network setting to offer multiple new services because providing guarantees to VoIP traffic requires extra network provisioning which can be provided only by tiered pricing to recover costs. It also requires a technology to package such service in forms that users can:

- purchase,
- provide the means for users to express their demand,
- signal the network to provide the requested quality, and
- generate accounting and billing records.

Edell and Varaiya [1999] showed that the demand for ISP service is sensitive to price and quality. Also, the differences in demand among users are persistent and large. The commodity form of the service (e.g., transport of traffic by volume or time) has a large impact on demand. Research also points towards usage-based pricing rather than the flat rate pricing.

Another challenge for service providers is to justify the upgrades required to build a fully converged network and recover the costs from their subscribers. The recent Telecom downturn is evidence that the "last mile" is indeed a very capital-intensive business and may require innovative service pricing strategies to obtain profitability. Usage-based pricing that reflects resource costs can promote the adoption of broadband access. Hence pricing lies at the heart of the value proposition of convergence and will likely require more research to understand.

REGULATORY AND POLICY ISSUES

The Telecommunications Act of 1996 was intended to create an open marketplace where competition and innovation can move as quickly as light. In the six years since the signing of the

Act, the telecom industry is in worse condition than ever before. Industry-wide revenues are contracting; profits are disappearing as prices of services plummet. Both established giant firms and upstarts, face the real threat of collapsing or shutting down. With Baby Bells controlling of 91.5% of all phone lines [Rosenbush and Elstrom, 2001] the local telecom markets remain almost a complete set of monopolies. As a result, the services provided to consumers are limited. In 2000, less than 5% of U.S. households had any type of broadband access [Rosenbush and Elstrom, 2001]. Most of these problems can be attributed to

- governmental subsidy to local phone companies,
- Baby Bell monopolies, and
- the use of lawsuits by the Bells to eliminate or delay competition.

The way radio spectrum is assigned to government-related or broadcast agencies, the old fashioned criteria of antitrust law to block or approve mergers in the telecom industry, the lack of deploying new technologies based on Internet protocols and open standards all point to the need for a fresh look at the regulatory environment as convergence proceeds. Should the overhaul come from state and federal regulators, who must remain deeply involved in the industry even though the Telecom Act was touted as "deregulation"? What rules and regulations should be established that will spur capital investment and spur innovation? How can regulators promote competition to open up a "new" converged network that can deliver new and enhanced services? Should subsidies in local phone markets be removed so that competitors can battle for customers? In rural areas, should government subsidize the rollout of broadband network connections to make it profitable for Bells, cable companies and other providers to invest in more converged networks? In wireless, should FCC make more spectrum space available to those companies that are ready to invest billions to deliver new services? Finally, to get the industry going, how can one stop the endless litigation and offer a more effective arbitration process for minor disputes? Streamlining decision-making by regulators and courts can eliminate delays that thwarted the Telecom Act.

So far, services such as Internet telephony are little regulated. This inattention, while good for the entire convergence industry, can change anytime due to political changes. Regulatory activities sometime benefit integration of Telecommunications and Internet while sometime inadvertently may hurt it. An extreme example is where Internet Telephony is banned (such as Mexico and China). Partly this ban results from IP telephony competing as an alternative to legacy telephone systems that are government owned entities enjoying monopoly status. The other reason is that by placing a ban on gateways, it is easy to shut out the PC-to-phone class of traffic. It is inherently difficult to prohibit PC-to-PC telephony since, unless one looks at packet payload, this traffic looks like a data application.

SOCIAL ACCEPTANCE OF EMERGING TECHNOLOGY ISSUES

The technology adoption lifecycle model comes in two versions:

- One version describes the market acceptance of new products in terms of innovators, early adopters, early majority, late majority, and laggards. The adoption process follows the logistics curve and can be illustrated as a classic normal distribution.
- The second version is a modification of the first version that includes a gap in the logistics curve between early adopters and the early majority (Figure 5). This gap essentially splits the adoption process into three distinct phases:

    1. an early market,
    2. a mainstream market, separated by
    3. a period of time called the valley of death.

For high-tech products, Geoffrey Moore calls this gap "crossing the chasm" [Moore, 1999].

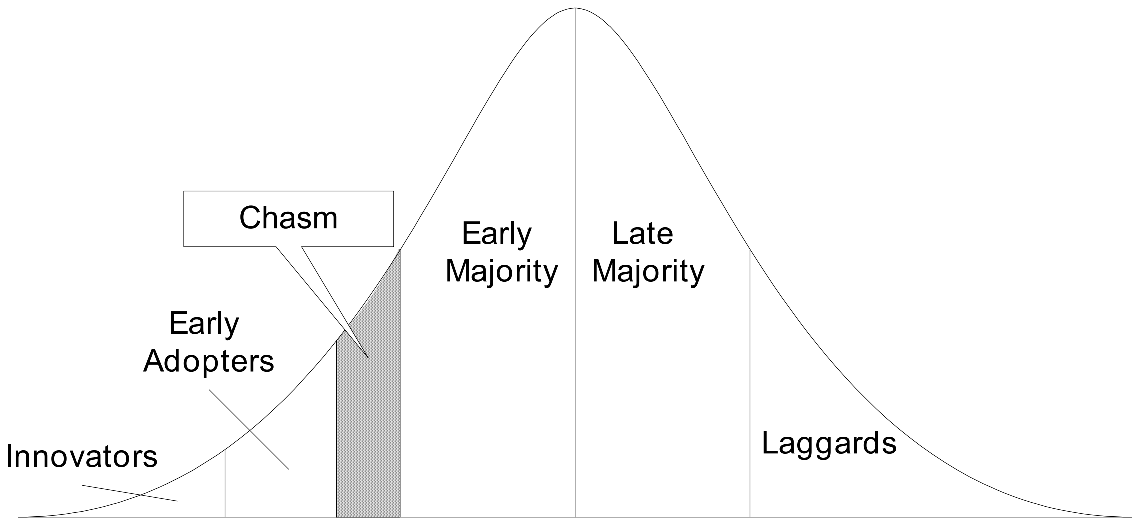


Figure 5. Technology Adoption Curve Showing Moore's Chasm

Both versions of the technology adoption lifecycle are useful tools for understanding the way markets unfold and mature. However the "valley of death" version typically applies to discontinuous innovations that force the user to change behavior. Not all high-tech products are discontinuous, so care must be used in selecting the appropriate adoption cycle The open standards of the Internet also led to social transformations as evidenced by the Napster music file sharing service. Convergent platforms would promote this change more [Moore, 1999].

Peer-to-peer technologies (P2P) enable bandwidth sharing, dynamic collaboration, and distributed computing that are attracting enterprises to exploit new forms of business communications [Liben-Nowell et al., 2002]. Philosophically, enabling peers and/or edge devices to communicate, collaborate, and transact in a decentralized manner, squarely conflicts with the conventional tradition of using centralized and hierarchical operating structures of enabling communication, collaboration, and transaction. Decentralization takes control of information out of the hands of power brokers within the system, be they enterprises or governments. Potentially, P2P can evaporate the distinction between the edge and core and truly enable the small- to medium-sized companies that make up the edge to participate actively in value and wealth creation in their market space.

VII. CONCLUSION: THE HIGH VELOCITY SPIRAL

How can senior managers leverage network convergence? After decades of largely autonomous communications industries acting as information conduits, we are on the verge of a revolution in which high capacity networks can deliver seemingly unlimited information, whose timing and content can be controlled by users. Network convergence directly speeds up productivity and innovation that are both applications of knowledge to work. A converged telecommunication network and application of knowledge are inseparably bound to one another.

Managers can leverage converged networks in several ways:

- to perceive and react to their environment,
- to sense competitor moves,
- to organize timely response,
- to deal with globalization pressures and
- to gain and retain customers.

Convergence distinguishes itself by accuracy, immediacy, and richness of information. It plays a pivotal role in shaping the high-velocity spiral shown in Figure 6.

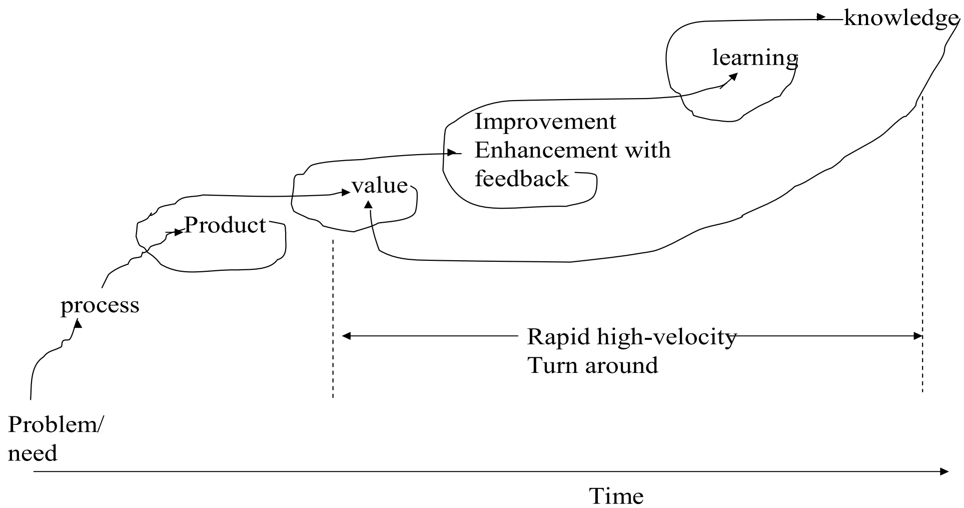


Figure 6. The High-Velocity Spiral Fueled by Convergence

As problems are identified, new processes are created which lead to products or services that add value to a customer's needs. Through continual feedback, enterprises learn more about the product or service, which then becomes corporate knowledge. The cycle from start to finish is expected to occur at high velocity.

As with any new Information Technology, the value proposition and return on investment must be justified. Some benefits are tangible short-term benefits but most are long-term and intangible. The latter are often harder to value monetarily. Converged networks provide several values.

- A clear tangible short-term benefit to converged networks is to eliminate legacy infrastructures (PBXs, telephones) and integrate all communications over a single IP network that is easier to manage. The cost savings is significant.
- A converged network will deliver seemingly unlimited information at a high speed. More data and information can be communicated and shared in a 'rich' format, which means voice, video, and image will go together. This 'rich' or multimedia information may enhance the overall quality of corporate decision-making by reducing the equivocation of the information. [Lim and Benbasat, 2000]
- Information in the converged network will be personalized to fit the customer's individual needs. Converged network users can control the timing and content of the transmitted information. Relevant information can reduce the time to make decisions.
- Finally, the converged network will provide mobility to users. Users will use various wireless devices to connect to the converged network. This mobility will reduce the time-to-respond to market changes and competitor's strategies.

Better decision support systems and management information systems can be built by interfacing to a converged network and using the real-time benefits of accessing voice, video and data all at the same time.

The key to success in tomorrow's global competitive landscape lies in the most effective storage, dissemination, and management of corporate knowledge assets. Converged networks could well be the survival lifelines for doing that.

EDITOR'S NOTE: This article is based on a tutorial presented at AMCIS 2002. The article was received on June 27, 2002. It was with the author five months for 1 revision. It was published on November 19, 2002.

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EDITOR'S NOTE: The following reference list contains the address of World Wide Web pages. Readers who have the ability to access the Web directly from their computer or are reading the paper on the Web, can gain direct access to these references. Readers are warned, however, that

1. these links existed as of the date of publication but are not guaranteed to be working thereafter.
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LIST OF ACRONYMS

ADSL	Asynchronous Digital Subscriber Line
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAM	Computer Aided Manufacturing
CATV	Community Antenna Television
CLEC	Competitive Local Exchange Carrier
CODEC	Compression/Decompression Module
CRM	Customer Relationship Management
CTI	Computer Telephone Integration
ERP	Enterprise Resource Planning
FCC	Federal Communications Commission
FTP	File Transfer Protocol
HFC	Hybrid Fiber Coax
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
IETF	Internet Engineering Task Force
ILEC	Incumbent Local Exchange Carrier
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
IVR	Interactive Voice Response
LAN	Local Area Network
LMDS	Local Multipoint Distribution Service
OLTP	On-Line Transaction Processing
PBX	Private Branch Exchange
PDA	Personal Digital Assistant
POTS	Plain Old Telephone System
PSTN	Public Switched Telecommunications/Telephone Network
SCM	Supply Chain Management
SIP	Session Initiation Protocol
SOAP	Simple Object Access Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
UDDI	Universal Description, Discovery and Integration
VoIP	Voice over Internet Protocol
WAP	Wireless Application Protocol
WSDL	Web Services Description Language

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Communications of the Association for Information Systems

ISSN: 1529-3181